DOCUMENT RESUME

ED 109 220 TM 004 681

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TITLE The Effects of Arousal on Recall and the Organization of Memory.
PUB DATE Nov 73
NOTE 12p.; Paper presented at the Annual Meeting of the Psychonomic Society (Saint Louis, Missouri, November 1973)

EDRS PRICE MF-$0.76 HC-$1.58 PLUS POSTAGE
DESCRIPTORS *Arousal Patterns; Cognitive Processes; Literature Reviews; *Memory; *Models; *Recall (Psychological); *Stimulus Behavior; Verbal Learning

ABSTRACT

The effects of arousal on verbal learning and memory are presently controversial. Investigators using different definitions of arousal, different tasks, and different methods have (as one would expect) produced different findings in the literature: (a) Arousal during acquisition leads to poor immediate but better delayed recall; (b) Arousal during acquisition sometimes facilitates immediate as well as delayed recall; (c) Arousal may lead to decrease in semantic clustering: (d) Arousal may facilitate recall for material in which "order" cues are salient: and (e) Arousal may lead to a convergence in decision criteria while at the same time increasing sensitivity for certain kinds of material. Instead of five separate explanations, the paper proposes to account for these effects by a single explanatory model based on the effects of arousal on memory organization. A model, based on changes in the way material is organized for retrieval is developed which views arousal as facilitating memory when recall is based on the physical characteristics of stimuli and hindering recall when memory depends on the semantic aspects of the stimuli. The implications of this model for the research findings decribed in the literature are discussed. (Author)

Paper presented at the annual meeting of the Psychonomic Society, Saint Louis, November, 1973.

The Effects of Arousal on Recall and the Organization of Memory

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Prior to the past decade little attention was paid to the motivational aspects of verbal learning. Recent years, however, have seen the development of a literature providing some insight into the role of arousal in verbal learning and memory.

Unfortunately, it is not at all easy to classify this literature into neat conceptual categories because researchers working from different persepectives have madeuse of a variety of experimental techniques to study various types of verbal materials. Thus, some investigators have concentrated on paired-associate learning (e.g. Kleinsmith & Kaplan, 1963;1964), others on the free recall of word lists (e.g. Maltzman, Kantor, and Langdon, 1966), and still others on narrative and even cinematic materials (Levonian, 1967; Schwartz, 1973b).

To confuse matters further, experimenters tend to employ different definitions of arousal. For example, the choice of a physiological indicant of arousal may differ from one experiment to another and some experiments make use of no physiological indicators at all. Moreover, in some studies a distinction is made between arousal level and arousal increment while others make no such distinction. Because of these differences in materials studied and arousal measures employed no simple conclusions can be reached concerning the role of arousal in verbal learning and information processing. Nevertheless,

hypotheses have been advanced and will be explored. In order to examine the various hypotheses, it is useful to elucidate, as clearly as possible, given the problems already described, exactly what are the findings that need to be explained. Keeping in mind the methodological differences already mentioned, five general types of findings may be identified.

The first type of finding is associated with Kleinsmith & Kaplan (1963;1964) who reported that arousing paired associate items were harder to remember than non-arousing items when recall was tested immediately after acquisition but better recalled when retention was tested after delays lasting up to one week. This finding was thought to support the hypothesis that arousal protects a neural trace from interference (by rendering it inaccessible) until it is consolidated (Walker, 1958).

Although similar results have been reported by others (Berlyne, et. al., 1965;1966; Levonian, 1967; Mclean, 1969) a great deal of conflicting evidence (e.g. Hörmann & Todt, 1960; Maltzman, Kantor, & Langdon, 1966; Schönpflug, 1966) suggests that the consolidation hypothesis is incorrect. This conflicting evidence constitutes the second type of result that needs to be explained. That is, sometimes increases in arousal during acquisition facilitate immediate as well as delayed recall. Thus, although it appears that arousal during acquisition influences subsequent memory, the precise arousal-recall relationship is unclear.

In a recent attempt to reconcile these two divergent results, Levonian (1972) advanced a hypothesis centering on a disctinction between arousal's effect on retentivity and its effect on accessibility. Since

memory, in some experiments, improved from immediate to delayed recall, arousal could not have resulted in any permanent information loss. It seems quite plausible, therefore, to assume that arousal affects the accessibility of stored information. Levonian goes on to account for the discrepant findings described thus far in terms of differences in their experimental procedures which may have resulted in varying rates of habituation (and arousal) for different list items. The discrepant results therefore, may have been due to the use of differentially arousing lists and list orders. Levonian was concerned with only the first two types of results already described. He did not address himself to three additional types of findings reported in the literature.

For example, a third type of finding was reported by Hörmann & Osterkamp (1966), namely that white-noise induced arousal leads to a decrease in semantic clustering in free recall. Similar findings have been reported for anxiety-induced arousal (Mueller & Goulet, 1973).

A fourth type of result is related to the third and is associated with the work of Hockey and Hamilton (Hamilton, et. al., 1972; Hockey & Hamilton, 1970). In their experiments, arousal was found to improve immediate recall only when order cues were useful in retrieval and not when such cues were irrelevant to recall.

Finally, a fifth type of result was obtained by Schwartz (1973b). Employing a decision theory framework, memory for the surnames of characters in short stories was tested in a recognition experiment. Under non-arousing conditions, Ss employed a risky criterion for common names and a cautious criterion for rare names. Aroused Ss, on the other hand, employed a similar criterion for the recognition of both rare and common names. Common names were still remembered better than rare names under arousal due to an increase

in sensitivity for such names.

There are, therefore, five types of experimental results that need to be explained:

(a) Arousal during acquisition can lead to poor immediate but superior delayed recall.

(b) Arousal during acquisition may lead to superior immediate as well as delayed recall.

(c) Arousal can lead to a decrease in semantic clustering in recall.

(d) Arousal may facilitate recall for material in which "order" cues are salient.

(e) Arousal during acquisition may lead to a convergence in decision criteria while at the same time increasing sensitivity for some kinds of material.

As noted earlier, the various experiments that gave rise to these results, employed different materials, arousal indices and experimental paradigms. For this reason it should come as no surprise that separate explanations have been advanced to account for each of the results. It is my present purpose, however, to propose a single explanation based on a model designed to account for all five types of findings.

If we take as our starting point the fact that in some experiments memory improved from immediate to delayed recall, some explanation relating arousal to accessibility seems clearly necessary. It is not necessary, then, to argue with Levonian's assertion that arousal affects the accessibility of stored information but rather to extend this notion in order to account for the effects on clustering, order cues and decision criteria.

Such an extension may be effected by hypothesizing that arousal effects the way material is organized in memory. Depending on the type of material, arousal may either facilitate or hinder its retrieval. Contradictory experimental findings would be expected depending on the nature of the material to be recalled.

Broadbent (1971) has identified two retrieval strategies, filtering and pigeon-holing. Filtering occurs when one adopts a "stimulus set ", choosing items to be remembered on the basis of some common feature (acoustic similarity, for example) and ignoring those items in the store without this feature. Filtering, therefore, involves the grouping of input on the basis of its physical characteristics. Pigeon-holing, on the other hand, occurs when one adopts a "response-set" selecting from a large number of items (e.g. a list of words), those constituting a subvocabulary (e.g. the names of colors). Thus, filtering results in stimulus selectivity, whereas pigeon-holing results in response selection. When an operating characteristic is derived relating the probability of a correct response to the probability of an error (false alarm), pigeon-holing produces an increase in the number of correct responses as the false alarm rate rises, whereas filtering produces a change in the number of correct responses with a constant false alarm rate. In decision theory terms, filtering is mirrored by changes in $\underline{d}'$ and pigeon-holing by changes in β.

If we return to the Schwartz (1973b) finding that arousal affects memory by decreasing pre-existing differences in β (see Figure I) it seems that pigeon-holing, a useful strategy under non-arousing conditions, is no

longer an effective strategy when acquisition is accompanied by arousal. As the effectiveness of pigeon-holing decreased, (see Fig. 2), d' (at least for common names) increased. In immediate recall, therefore, arousal improved filtering but made pigeon-holing more difficult.

The differential effects of arousal on filtering and pigeon-holing may also explain the findings regarding clustering and order cues.

Since semantic clustering does involve the formation of sub-vocabulary response sets it depends on pigeon-holing as defined above. Thus, the finding that clustering decreased with arousal is in line with the effect of arousal on pigeon-holing described by Schwartz. Similarly, the increased ability to use order cues is likewise not surprising as such cues are those employed by a filtering strategy and the Schwartz result indicated that filtering can be facilitated by arousal.

It is not quite so easy to apply the current explanation to the results indicating that delayed and immediate recall may sometimes be differentially affected by arousal. Consistency demands that these results be explained by assuming that when immediate recall was facilitated that the material employed was subject to recall by filtering and that when immediate memory was hindered, the material could only (or best) be recalled by pigeon-holing. The change in the effects of arousal over time reported in some studies may have been due to arousal's dissipation with time. A partial test of this hypothesis by Schwartz (1973a) seemed to indicate that the negative effects of arousal on pigeon-holing do tend to dissipate with time.

The explanation for the various effects of arousal on recall offered here may be summarized quite briefly. It is hypothesized that arousal affects the accessibility of stored information by making pigeon-holing more difficult and filtering easier. Depending on the type of material to be remembered, arousal could facilitate or hinder immediate recall. In addition, the negative effects of arousal on pigeon-holing may dissipate with time. The actual effect of arousal in any particular experiment would be a function of the interaction of a number of factors including the nature of the material to be recalled, the plausibility of pigeon-holing and the efficacy of filtering for recalling the particular materials of interest.

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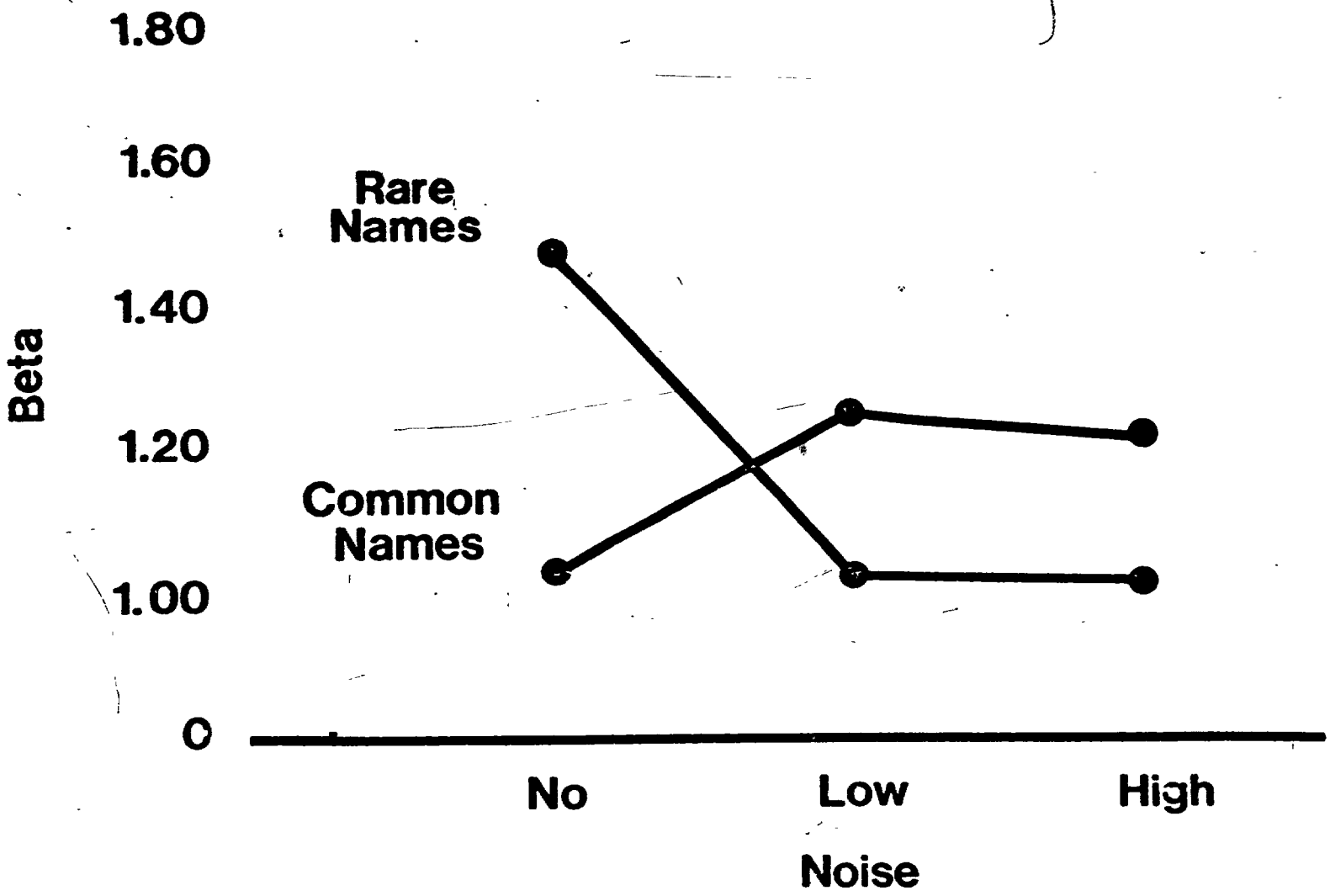

From Schwartz, 1973B.